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ABUNDANCE OF THE NORTHERN PIKE POPULATIONS OF  
GEORGE, VOLKMAR, AND T LAKES WITH ESTIMATES  
OF AGE, SEX, AND LENGTH COMPOSITION, 1988<sup>1</sup>

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# TABLE OF CONTENTS

	<u>Page</u>
LIST OF TABLES.....	ii
LIST OF FIGURES.....	iii
LIST OF APPENDICES.....	iv
ABSTRACT.....	1
INTRODUCTION.....	2
Study Areas.....	2
Study Goals and Objectives.....	6
METHODS.....	7
Abundance Estimation.....	8
George Lake.....	8
Volkmar Lake.....	9
T Lake.....	9
Composition Estimation.....	10
Length Frequency Distribution.....	11
Length-at-Age Estimation.....	11
RESULTS.....	12
George Lake.....	12
Volkmar Lake.....	12
T Lake.....	23
DISCUSSION.....	23
ACKNOWLEDGEMENTS.....	30
LITERATURE CITED.....	30
APPENDIX.....	34

# LIST OF TABLES

<u>Table</u>	<u>Page</u>
1. Annual recreational fishing effort and harvest of sport fish from George Lake, 1977 through 1987.....	5
2. Relative stock densities (RSD), expressed as percentages, of northern pike in George, Volkmar, and T Lakes in 1986, 1987, and 1988.....	13
3. Sex compositions of the northern pike populations of George and T Lakes in 1988 by three size groups.....	14
4. Mean length (mm), by age and sex, of northern pike in George Lake in 1988.....	16
5. Age composition of northern pike (> 299 mm) in George Lake in 1988.....	17
6. Mean length (mm) by age (sexes combined) of northern pike sampled from Volkmar Lake in 1988.....	20
7. Parameter estimates of the von Bertalanffy growth equation for Volkmar, George, and T Lakes.....	21
8. Mean length (mm), by age and sex, of northern pike from T Lake in 1988.....	25
9. Age composition of northern pike in T Lake in 1988.....	26

# LIST OF FIGURES

<u>Figure</u>	<u>Page</u>
1. Location of George, Volkmar, and T Lakes, Alaska.....	3
2. Length frequency distribution of northern pike in George Lake in 1988.....	15
3. Age distribution of northern pike in George Lake in 1988.....	18
4. Length and age distributions of northern pike in Volkmar Lake in 1988.....	19
5. Von Bertalanffy growth curves of male and female northern pike in Volkmar Lake.....	22
6. Length frequency distribution of northern pike in T Lake.....	24
7. Age distribution of northern pike in T Lake in 1988.....	27
8. Von Bertalanffy growth curves of female and male northern pike in George, Volkmar, and T Lakes.....	29

## LIST OF APPENDICES

<u>Appendix</u> <u>Table</u>	<u>Page</u>
1. Fin clips and tags assigned to northern pike in George, Volkmar, and T Lakes.....	35
2. Abundance of small (300-449 mm), medium (450-749 mm), and large (> 749 mm) northern pike in George, Volkmar, and T Lakes in 1986, 1987, and 1988.....	36

# ABSTRACT

Populations of northern pike *Esox lucius* in George, Volkmar, and T Lakes, in interior Alaska, were studied during the spring of 1988. Estimated abundance of northern pike over 299 millimeters, during May 1988, was 23,381 and 465 fish for George and T Lakes, respectively. An estimate of abundance was not obtained for northern pike in Volkmar Lake for 1988. Of the three lakes, T Lake had the greatest relative stock density of preferred and memorable fish. Female northern pike from the three lakes had similar age-length relationships, but males from Volkmar Lake were smaller at older ages than males from the other two lakes. Sport fishery exploitation rates are discussed.

KEY WORDS: Northern pike, *Esox lucius*, George Lake, Volkmar Lake, T Lake, Alaska, abundance, mark-recapture, growth, length-at-age, age composition, sex composition, exploitation.

## INTRODUCTION

Northern pike *Esox lucius* have become increasingly popular with sport anglers of interior Alaska in recent years. According to the most current estimates of sport fish harvest in interior Alaska, northern pike rank fifth for all species and third for indigenous stocks (Mills 1988). Harvests of northern pike in interior Alaska averaged about 15,000 fish between 1977 and 1987 (ranging from 11,600 to 19,000) with more recent harvests at about 14,200 fish (Mills 1988). Interior Alaska accounts for 75% to 90% of the statewide harvest of Alaskan northern pike on an annual basis with waters of the Tanana River drainage accounting for about 65% of the regional harvest. George and Volkmar Lakes are among the most popular fishing areas for northern pike in the Tanana River drainage. A third lake, T Lake, receives an unknown, but probably low level, of fishing pressure.

Periodic stock assessment and creel census studies of northern pike resources and fisheries of the Tanana River drainage were conducted from 1971-1984 (Peckham 1972-1985). Research conducted at Volkmar Lake in 1985 (Peckham 1986) provided the first estimate of northern pike abundance in Alaska along with information on the life history of this population. Research conducted during 1986 and 1987 provided additional estimates of abundance along with catch-per-unit-of-effort (CPUE) statistics, catchability coefficients, and life history characteristics for northern pike in Volkmar, T, and George Lakes (Peckham and Bernard 1987, Clark et al. 1988, Clark 1988, Clark and Gregory 1988). This report documents the research conducted in 1988 concerning the abundance and age, sex, and length compositions of the populations of northern pike in these waters.

### Study Areas

Volkmar Lake (64°07'30"N, 145°11'W) is a remote 273 hectare (ha) lake located approximately 25 kilometers (km) northeast of the town of Delta Junction (Figure 1). The lake lies at an elevation of 326 meters (m) and has a maximum depth of 12.8 m. The lake has two small inlets and an ill-defined seasonal outlet that drains westerly into the flats towards the Goodpaster River. Volkmar Lake is usually ice-free from mid-May through early October. Nearshore waters, which are shallow, support extensive beds of aquatic vegetation which provide northern pike with spawning substrate as well as rearing and feeding habitat for juvenile and adult fish. The lake is accessible during the open water season by float-equipped aircraft and airboats; snow machines and ski-equipped aircraft provide access during the winter.

The recreational popularity of Volkmar Lake is growing because of recent State land disposals around the lake, because of improved winter access from new snow machine trails and roads in the Delta Agricultural Project, and because of increased summer and winter use by cabin owners around the lake and from the nearby Goodpaster River. About 15 recreational cabins are presently located along the lake shore, and others are being constructed. In 1987 a sport fishing lodge was established on the eastern shore of the lake. The lodge operator has intermittently provided transportation, living facilities, and boats for recreational anglers during the open water season. These



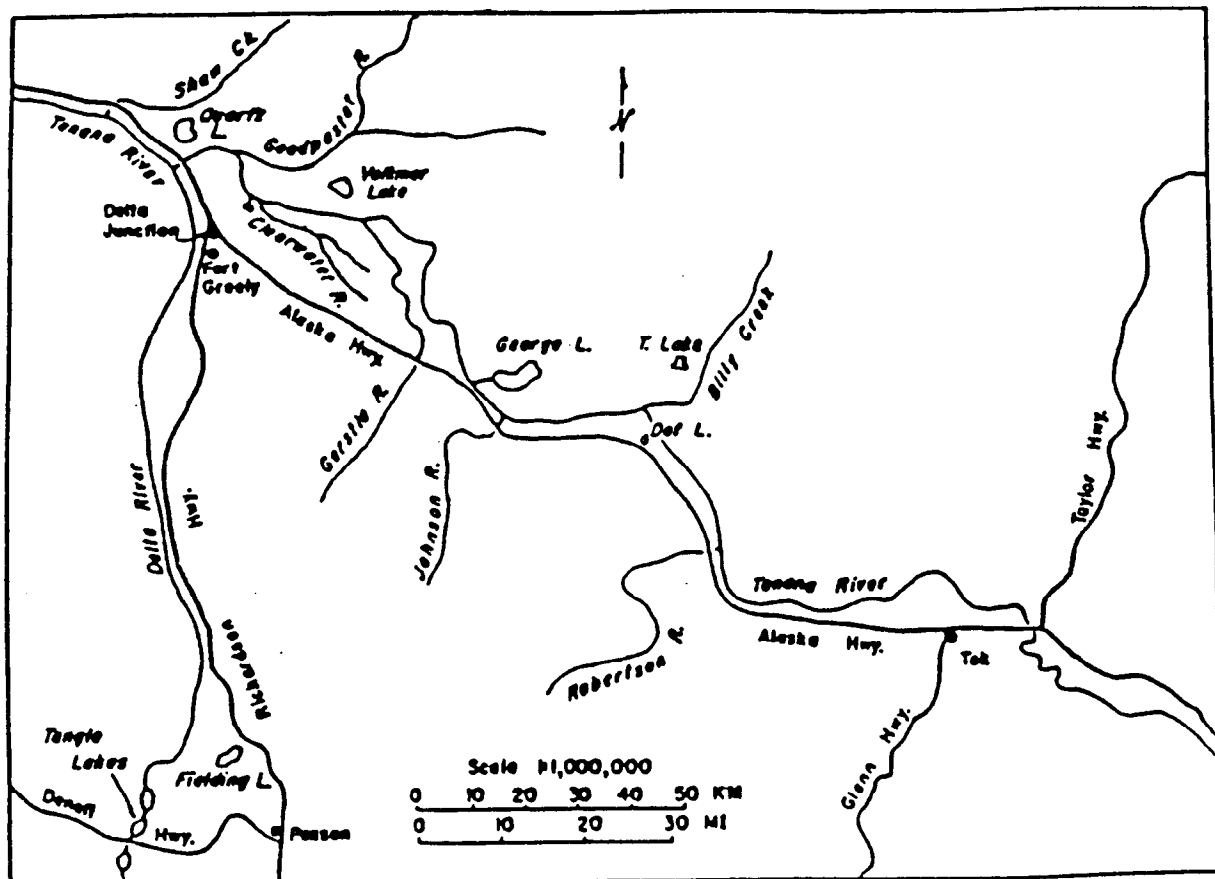


Figure 1. Location of George, Volkmar, and T Lakes, Alaska.

various facilities are used by recreational fishermen attracted to Volkmar Lake for open water angling. Other anglers fly to Volkmar Lake for day trips or camp along the shoreline. In addition, winter spear and hook-and-line sport fisheries at Volkmar Lake are increasing. Other fish species present include humpback whitefish *Coregonus pidschian*, least cisco *Coregonus sardinella*, and slimy sculpin *Cottus cognatus*.

Fishing pressure in Volkmar Lake is moderate, ranging from 273 to 546 angler-days per year (Clark and Gregory 1988). Since 1977, harvest of northern pike in Volkmar Lake has been reported in the statewide angler survey in only 3 of 10 years. In 1981, 648 northern pike were harvested during 458 days of fishing; 777 northern pike were harvested during 546 days of fishing in 1982; 430 northern pike were harvested during 430 days of fishing in 1983 (Mills 1982, 1983, 1984). An estimated 657 northern pike were harvested in Volkmar Lake during 1986. More current harvest estimates are unavailable. There are currently no known subsistence or commercial fishery harvests in Volkmar Lake.

George Lake (63°47'N, 144°31'W) is a semi-remote 1,823 ha lake located approximately 8 km northeast of the Tanana River and the Alaska Highway about 45 km southeast of the town of Delta Junction (Figure 1). George Lake lies at an elevation of 389 m and has a maximum depth of 11.0 m. The lake has one major inlet, six smaller inlets, and an outlet (George Creek) that flows into the Tanana River. George Lake is usually ice free from late May through mid-October. Nearshore waters are shallow, supporting extensive beds of aquatic vegetation which provide northern pike with spawning substrate as well as rearing and feeding habitat for juvenile and adult fish.

George Lake is accessible during the open water season by boat via the Tanana River and the outlet, George Creek, or by float-equipped aircraft. Although George Creek is navigable by boat, it is shallow, requiring a boat powered with a jet unit or an outboard equipped with a lifting device. Snow machines and ski-equipped aircraft provide a means of access during the winter. Two privately-owned recreational cabins are located along the lake shore, the remainder of the land being claimed by various Native corporations. These cabins, along with various camping sites, are used by recreational fishermen attracted to George Lake for open water angling for northern pike. In addition, there is a winter spear and hook-and-line sport fishery for northern pike. No known subsistence or commercial fishery harvests currently exist.

Fishing pressure in George Lake is moderate: from 1977 to 1987 effort ranged from 0.5 to 1.1 annual angler days per hectare (0.5 to 1.1 AAD/ha). Annual fishing effort averaged 1,041 days from 1977 through 1983 (0.57 AAD/ha) and increased to an average of 1,451 days (0.80 AAD/ha) from 1984 through 1987 (Table 1). Fishing effort substantially increased in 1986, when 1,321 anglers made 1,091 trips and spent 1,957 days fishing (1.07 AAD/ha) in George Lake to catch an estimated 3,076 northern pike. Estimated catch and effort declined in 1987 when 1,247 anglers spent 1,467 days (0.80 AAD/ha and 1.77 days/trip) to harvest 2,229 northern pike. The estimated annual harvest of northern pike by recreational fishermen averaged 1,604 fish (0.88/ha) from 1977 through 1983, 2,419 fish (1.33/ha) from 1984 through 1987, and 1,900 (1.04/ha) for the entire 11 year period. The most recent (1987) harvest estimate of 2,229

Table 1. Annual recreational fishing effort and harvest of sport fish from George Lake, 1977 through 1987.<sup>1</sup>

Year	Fishing Effort			Harvest by Species			
	Anglers	Trips	Fishing Days	White-fish	Grayling	Burbot	Northern Pike
1977			854	12	0	5	1,227
1978			1,271	0	27	0	1,392
1979			903	9	9	64	2,018
1980			1,057	0	17	0	1,395
1981			1,351	0	6	68	2,236
1982			989	0	0	31	1,635
1983			860	0	0	105	1,322
1984	557	523	1,254	65	65	143	1,700
1985	811	844	1,127	70	0	105	2,670
1986	1,321	1,091	1,957	0	134	32	3,076
1987	1,247	831	1,467	0	0	0	2,229
Averages							
1977-1983			1,041	3	8	39	1,604
1984-1987	984	822	1,451	34	50	70	2,419
All Years	984	822	1,190	13	23	50	1,900

<sup>1</sup> Source: Mills (1979 - 1988).

northern pike (1.22/ha) in George Lake represents the fourth largest annual harvest of northern pike documented for this lake since 1977.

Anglers at George Lake target northern pike, although other fish species are present, including Arctic grayling *Thymallus arcticus*, burbot *Lota lota*, humpback whitefish, least cisco, round whitefish *Prosopium cylindraceum*, longnose suckers *Catostomus catostomus*, and slimy sculpin. Arctic grayling and round whitefish are only occasionally captured in the lake by anglers and by test netting during research surveys.

T Lake (63°48'N, 143°53'W) is a remote fly-in 158 ha lake located approximately 17.7 km north of the village of Dot Lake along the Alaska Highway (Figure 1). The lake lies at an elevation of 434 m and has a maximum depth of 17 m. The lake has two small inlets and an outlet that flows from the northeast corner of the lake into Billy Creek. Annual discharge in the outlet, which is undocumented and believed to be intermittent, flows primarily during June following spring melt. Nearshore waters are shallow and support beds of aquatic vegetation which provide northern pike with spawning substrate, in addition to feeding and rearing habitat. T Lake is typically ice-free from mid-May to early October.

Two recreational cabins are located along the shore of T Lake. Recreational fishing pressure in T Lake is unknown but probably light (less than 50 angler days per year); however, the lake is relatively small and indigenous stocks likely cannot support a major intensive sport fishery. Fish species present, in addition to northern pike, include burbot, humpback whitefish, and least cisco.

#### Study Goals and Objectives

The goals of this research program are the assessment of northern pike stocks in Volkmar, George, and T Lakes, the investigation of the biology of these populations, and ultimately the formulation of sustainable effort and yield guidelines for these and other Alaskan fisheries on northern pike. Although limited sampling was conducted in Volkmar Lake in 1983 and 1984, intensive sampling began in 1985 when abundance of northern pike was first estimated and data on age, sex, length, and weight were also collected. During continued research conducted from 1985 through 1987, age, sex, length, and weight information were collected from captured northern pike and abundance was estimated for the northern pike populations in Volkmar Lake, for George Lake in 1987, and for T Lake in 1986 and 1987. In addition, efforts in Volkmar, George, and T Lakes were aimed at identifying a non-lethal, efficient means for capturing northern pike. Of the gears evaluated (gill nets, various trap and fyke nets, and seines), seines proved to be the most effective and least injurious to northern pike (Peckham and Bernard 1987).

Specific objectives of the 1988 research program were:

- 1) to estimate the abundance of northern pike (299 mm and longer) in Volkmar, George, and T Lakes; and,

- 2) to estimate the sex, length, and age compositions of the northern pike populations in Volkmar, George, and T Lakes.

In addition, other pertinent biological parameters determined through these investigations are reported.

## METHODS

Estimation of abundance of northern pike was attempted in all three lakes in 1988 with mark-recapture experiments. Prior sampling experience indicated that field studies of northern pike from lakes are best conducted during the spawning period immediately following spring ice melt. In George and T Lakes, two discrete sampling events took place in late May and early June 1988, with a three day hiatus between events in George Lake and a two day hiatus in T Lake. In Volkmar Lake, only one continuous sampling event took place in late May because of an unanticipated early breakup and spawning period. Sampling was conducted in all three lakes with a bag seine set from a boat and retrieved by hand to the shore. The seine was 66 m long and 3 m deep with 25 mm square mesh and was usually worked by a crew of four. Gill nets were also used in T Lake to capture northern pike because of limited success with seines (see Peckham and Bernard 1987 for gear specifications and gear fishing patterns).

During both mark and recapture events, captured northern pike were examined for previously implanted Floy FD-68 anchor tags and fin clips used to detect tag loss (Appendix Table 1), and were measured to the nearest millimeter of fork length with a metric measuring board. Each captured northern pike was classified by sex based either upon the presence of sexual products or the external characteristics described by Casselman (1974). Those northern pike for which the sex was uncertain were classified as unknown. Untagged northern pike larger than 299 mm were dorsally tagged with Floy tags and a fin was clipped corresponding to the current year's code (Appendix Table 1). Scales were removed from live fish to determine age as recommended by Williams (1955) and Casselman (1967). All live northern pike were returned to the water. To test for proper mixing of tagged fish for the population estimate, the lakes were divided into two or three sampling sections, and section of release and/or recapture was recorded for each marked fish.

Scales, basal vertebrae, and cleithra were taken from all northern pike killed during sampling to further supplement an on-going study of methods of age determination of northern pike (Peckham and Bernard 1987). Scales were stored in coin envelopes and later removed, cleaned, and mounted on gum cards. Gum cards were used to make scale impressions on 20 mil acetate using a Carver hydraulic press at 137,895 kPa (20,000 psi) heated to 93°C for 30 seconds. Scale impressions were read on a Micron 770 Microfiche reader. The formation of scale annuli in northern pike generally coincides with, or is presumed to closely follow, our sampling period during spawning in late May and early June. Therefore, ages were assigned either to match the observed formed annuli, or in the case of excessive circuli plus-growth, a year was added.

### Abundance Estimation

Assumptions necessary for the accurate use of abundance estimators are (Ricker 1975):

- 1) recruitment (emigration, immigration, and growth) is negligible;
- 2) marking does not affect catchability of fish in the recapture event (no trap sensitivity or differential natural mortality);
- 3) fish do not lose their marks between sampling events;
- 4) all marked fish are reported when recovered in the recapture sample;
- 5) all fish have an equal probability of being marked and released during the first sampling event or, all fish have an equal probability of being captured during the second sampling event or, marked and unmarked fish mix completely between events.

George Lake:

The Petersen method of estimating abundance through a mark-recapture experiment (Seber 1982) was discarded in favor of the stratified method of Darroch (1961) because the ratios of marked fish in the recapture event were significantly different between the three areas of the lake ( $\chi^2 = 19.50$ ,  $df = 2$ ,  $P < 0.05$ ), indicating that marked northern pike did not mix completely with unmarked fish, or that each fish did not have the same probability of being marked during the first event. However, other assumptions were fulfilled. Recruitment and tag loss was expected to be negligible because of the short hiatus period between events. Careful handling assured that all marked fish were reported and that differences in natural mortality between marked and unmarked fish were minimal.

In situations of partial mixing or unequal probabilities of capture, the stratified method of Darroch (1961) will produce an unbiased estimate of abundance. (See Clark et al. 1988 for detailed procedures for estimating abundance of northern pike in George Lake with the Darroch method.) The average of the 100 bootstrap abundance estimates was used as the estimate of abundance of northern pike in George Lake and the standard deviation of the 100 bootstrap estimates was used as the standard error of estimated abundance.

Kolmogorov-Smirnov tests (Zar 1984, p. 55) on lengths of fish captured in George Lake were used to determine if the gear was size-selective during either of the two sampling events. The lengths of fish marked during the first event were not significantly different from those recaptured during the second event ( $D = 0.15$ ,  $n = 1,189$ ,  $P = 0.211$ ) at  $\alpha = 0.05$ , but lengths of fish captured during the first event were significantly different from those captured during the second event ( $D = 0.07$ ,  $n = 2,225$ ,  $P = 0.009$ ) at  $\alpha = 0.05$ . Since size-selectivity was detected for the first event only, stratifying the abundance estimate by length was unnecessary, but lengths, sexes, and ages from the second sampling event only were used to estimate the proportions of the population in various classes.

Volkmar Lake:

Since only one sampling event occurred in Volkmar Lake in 1988, estimating abundance was not feasible. A post-season abundance estimate will be attempted in 1989, using the Jolly-Seber method (Seber 1982, p. 196).

T Lake:

Abundance ( $\hat{N}$ ) and variance of abundance ( $V[\hat{N}]$ ) of northern pike in T Lake was calculated with the Chapman modification of the single-mark Petersen estimator (Chapman 1951; Seber 1982, p. 266), according to the formulae:

$$(1) \quad \hat{N} = \frac{(C+1)(M+1)}{(R+1)} - 1; \text{ and,}$$

$$(2) \quad V[\hat{N}] = \frac{(C+1)(M+1)(C-R)(M-R)}{(R+1)^2(R+2)};$$

where:

C = number of fish captured during recapture event;

M = number of fish marked during marking event;

R = number of fish recaptured during recapture event.

The short duration of the hiatus in T Lake minimized the possibility of loss of tags, and also minimized the possibility of recruitment through migration or growth between the two sampling events. Careful handling of the northern pike in T Lake assured that differences in natural mortality between marked and unmarked fish were negligible, and that all marked fish were reported. The modified Petersen estimate of abundance was determined to be unbiased, as the ratios of marked fish in the recapture event were not significantly different between the two areas of the lake ( $\chi^2 = 0.22$ ,  $df = 2$ ,  $P < 0.05$ ), indicating that mixing of marked fish with unmarked fish was complete by the second event, or that each fish had the same probability of being marked during the first event.

Prior to selecting the Petersen abundance estimator, Kolmogorov-Smirnov tests (Zar 1984, p. 55) indicated that size-selectivity did not occur during either event. The lengths of fish marked during the first event were not significantly different from the lengths of fish recaptured during the second event ( $D = 0.06$ ,  $n = 214$ ,  $P = 0.999$ ) at  $\alpha = 0.05$ , and the lengths of all fish captured during the first event were not significantly different from the lengths of all those captured during the second event ( $D = 0.20$ ,  $n = 322$ ,  $P = 0.173$ ) at  $\alpha = 0.05$ . Therefore, one unstratified abundance estimate was made, and lengths, sexes, and ages from both sampling events were pooled to improve precision of proportions in estimates of composition.

### Composition Estimation

Abundance estimates and length, sex, and age composition data were used to provide estimates of the numbers of northern pike in the following categories:

1. Relative Stock Densities (RSD; Gabelhouse 1984) of "stock" (300-524 mm), "quality" (525-654 mm), "preferred" (655-859 mm), "memorable" (860-1,079 mm), and "trophy" (> 1,079 mm) length classes;
2. males and females;
3. age cohorts; and,
4. small (300-449 mm), medium (450-749 mm), and large (> 749 mm) length classes.

Only proportions of captured northern pike were calculated for Volkmar Lake, since an estimate of abundance for 1988 was not available. Sexes were combined for all estimates because sexes were obtained from only 38 northern pike in Volkmar Lake in 1988, due to the timing of the sampling period, which apparently occurred after spawning. For all three lakes, estimates of abundance of the small, medium, and large size classes were calculated only to provide a reference for comparing estimates of abundance to previous years, which required stratified estimates by size because of sampling bias.

Estimates and variances (Goodman 1960) of abundance in the various classes were based on the proportion of fish caught within a class to the total number of fish caught, according to the following equations:

$$(3) \quad \hat{P}_i = n_i/n;$$

$$(4) \quad V[\hat{P}_i] = \frac{\hat{P}_i(1-\hat{P}_i)}{n-1};$$

$$(5) \quad \hat{N}_i = \hat{P}_i(\hat{N}); \text{ and,}$$

$$(6) \quad V[\hat{N}_i] = (\hat{P}_i^2 V[\hat{N}]) + (\hat{N}^2 V[\hat{P}_i]) - (V[\hat{P}_i] V[\hat{N}]); \text{ where,}$$

$\hat{P}_i$  = estimated proportion of class i;

$n_i$  = number of fish sampled in class i;

$n$  = total number of fish sampled;

$V[\hat{P}_i]$  = variance of estimated proportion of class i;



$\hat{N}_i$  = estimated abundance of class i;  
 $\hat{N}$  = total estimated abundance;  
 $V[\hat{N}_i]$  = variance of estimated abundance of class i;  
 $V[\hat{N}]$  = variance of total estimated abundance.

### Length Frequency Distribution

Length frequency distributions, by 25 mm length categories, were calculated for males, females, and sexes combined for George and T Lakes, and for sexes combined only for Volkmar Lake. Calculations for George Lake were made using only data from the second sampling event because of sampling bias during the first event. Calculations for Volkmar Lake were made using raw data and were not adjusted for sampling bias because estimates of sampling bias were not available for fish sampled in 1988 in Volkmar Lake.

### Length-at-Age Estimation

Mean length-at-age was calculated as the arithmetic mean length at each age for males, females, and/or sexes combined for all three lakes. Standard errors for these mean length-at-age estimates were calculated in standard fashion using normal distribution theory.

Parameters of the von Bertalanffy growth equations (Ricker 1975, p. 221) for George, Volkmar, and T Lakes were calculated in previous years (Peckham and Bernard 1987, Clark et al. 1988, Clark 1988). The parameters for male and female northern pike from Volkmar Lake were updated in 1988 using data collected from 1983 through 1988, and were estimated through the Marquardt algorithm (Marquardt 1960). Since data from prior years were used, estimating the parameters by sex was possible. The von Bertalanffy growth equation is:

$$(7) \quad l_t = L_{\infty}(1 - e^{-K(t-t_0)}), \text{ where,}$$

$l_t$  = absolute growth;

$L_{\infty}$  = the theoretical maximum length;

$K$  = the Brody growth coefficient; and,

$t_0$  = the theoretical length at age 0.

Parameters were not tested for significant differences between years. Parameters were estimated 225 times, with the algorithm beginning with a new set of initial parameter estimates each time. Initial values were as follows:  $a(L_{\infty})$ : 400 to 1,200 by 200 mm;  $b(K)$ : 0.0 to 0.4 by 0.1; and  $c(t_0)$ : -2.0 to 2.0 by 0.5 mm. The set of estimates with the lowest least squares was selected as the best fit for that sex.

## RESULTS

### George Lake

A total of 2,250 northern pike (including recaptured fish) was sampled in George Lake in 1988. During the first event, 1,135 fish were released alive with tags. During the second event, 1,085 northern pike were examined for tags, of which 54 were tagged recaptures from the first event. The estimated abundance of northern pike larger than 299 mm in George Lake in late May of 1988 was 23,381 fish with a standard error (SE) of 6,471. Stock-sized fish accounted for the largest portion (64%) of the northern pike in George Lake in 1988, with decreasing numbers in the larger categories; no northern pike were estimated to be in the trophy category (Table 2). The density of northern pike larger than 299 mm was estimated to be 12.8 fish/ha.

The George Lake population of northern pike was comprised of 12,823 (55%) females and 10,558 (45%) males over 299 mm (Table 3). Males dominated the small length groups, while females dominated the larger groups (Figure 2). Females were generally larger than males for a given age (Table 4). Females tended to dominate the older age classes (ages 4 through 7), while males dominated the younger age classes (ages 3 through 4) (Table 5). The oldest northern pike captured in George Lake was age 14. Northern pike of both sexes appeared to be fully recruited to the sampling gear by age 4 (Figure 3), and by 450 mm for males and by 475 mm for females (Figure 2). Numbers of fish falling within the small, medium, and large size classes are given in Appendix Table 2.

### Volkmar Lake

A total of 490 northern pike was captured from Volkmar Lake during the one sampling period in 1988. Estimates of total abundance and density, and estimates of abundance of northern pike in various length, sex, and age categories, were not possible because a recapture event did not occur. Length frequencies, RSD, and age frequencies of northern pike were calculated only for sexes combined because of the limited number of sexed samples.

Northern pike captured in Volkmar Lake in 1988 were primarily grouped between 450 mm and 650 mm (Figure 4). Most sampled northern pike (47.8%) were stock-sized, although nearly 39% were quality-sized; few northern pike larger than 654 mm were captured in Volkmar Lake in 1988 (Table 2). Mean lengths by age ranged from 292 mm for age 2 fish to 737 mm for age 10 fish (Table 6). Most northern pike captured in Volkmar Lake were age 5 or 6 (Figure 4), and the oldest fish captured was age 12. Northern pike in Volkmar Lake appear to be fully recruited to the sampling gear by age 5 and 525 mm (Figure 4). Parameters for the von Bertalanffy growth equation were calculated by sex, since data from several years (including the 38 sexed northern pike from 1988) were combined, providing a large sample of sexed fish. The estimated  $L_{\infty}$  for males from Volkmar Lake was 741 mm;  $L_{\infty}$  for females was 1,079 mm (Table 7, Figure 5).

Table 2. Relative stock densities (RSD), expressed as percentages, of northern pike in George, Volkmar, and T Lakes in 1986, 1987, and 1988.<sup>1</sup>

	1986		1987		1988				
	RSD	SE RSD	RSD	SE RSD	RSD	SE RSD	<sup>^</sup> N	<sup>^</sup> SE N	n
<u>George Lake</u>									
Stock	69.3	2.4	74.3	1.6	64.2	1.5	15,009	4,167	692
Quality	22.1	2.2	20.9	1.5	26.5	1.4	6,203	1,743	286
Preferred	8.3	1.5	4.7	0.8	8.9	0.9	2,082	608	96
Memorable	0.3	0.3	0.0		0.4	0.2	87	48	4
Trophy	0.0		0.0		0.0		0	0	
<u>Volkmar Lake<sup>2</sup></u>									
Stock	58.7	0.5	66.0	0.6	47.8	5.5	-	-	218
Quality	33.8	0.5	27.3	0.3	38.8	5.2	-	-	177
Preferred	6.9	0.3	6.1	0.3	12.7	2.4	-	-	58
Memorable	0.6	0.1	0.6	0.9	0.7	0.1	-	-	3
Trophy	0.0		0.0		0.0		-	-	0
<u>T Lake</u>									
Stock	13.4	1.6	39.8	2.9	37.3	3.0	174	21	100
Quality	44.3	2.4	26.7	2.6	34.7	2.9	161	20	93
Preferred	40.9	2.3	31.7	2.8	25.8	2.7	120	17	69
Memorable	1.4	0.5	1.8	0.8	2.2	0.9	10	4	6
Trophy	0.0		0.0		0.0		0	0	0

<sup>1</sup> Stock = 300-524 mm, quality = 525-654 mm, preferred = 655-859 mm, memorable = 860-1,079 mm, and trophy = 1,080 mm and larger.

<sup>2</sup> Estimates of abundance were not available for Volkmar Lake in 1988.

Table 3. Sex compositions of the northern pike populations of George and T Lakes in 1988 by three size groups.<sup>1</sup>

	Small	Medium	Large	>299	>449
<u>George Lake</u>					
Sample Size	278	673	19	970	692
Number Females	71	442	19	532	461
Number Males	207	231	0	438	231
Total Abundance	6,701	16,222	458	23,381	16,680
Proportion Female	0.26	0.66	1.00	0.55	0.67
SE Proportion	0.03	0.02	0	0.02	0.02
Abund. Females	1,711	10,654	458	12,823	11,112
SE Abundance	510	2,971	161	3,567	3,097
Proportion Male	0.74	0.34	0.00	0.45	0.33
SE Proportion	0.03	0.02	0	0.02	0.02
Abundance Males	4,990	5,568	0	10,558	5,568
SE Abundance	1,412	1,571	0	2,944	1,571
<u>T Lake</u>					
Sample Size	45	192	24	261	216
Number Females	6	96	23	125	119
Number Males	39	96	1	136	97
Total Abundance	73	350	42	465	392
Proportion Female	0.13	0.50	0.96	0.48	0.55
SE Proportion	0.05	0.04	0.04	0.03	0.03
Abund. Females	10	175	40	223	216
SE Abundance	4	21	9	25	23
Proportion Male	0.87	0.50	0.04	0.52	0.45
SE Proportion	0.05	0.04	0.04	0.03	0.03
Abundance Males	63	175	2	242	176
SE Abundance	11	21	2	27	21

<sup>1</sup> Sex compositions were estimated by small (299-449 mm), medium (450-749 mm), and large (> 749 mm) length categories to provide a reference for comparing estimates of abundance to previous years, which required stratified estimates by size because of sampling bias.

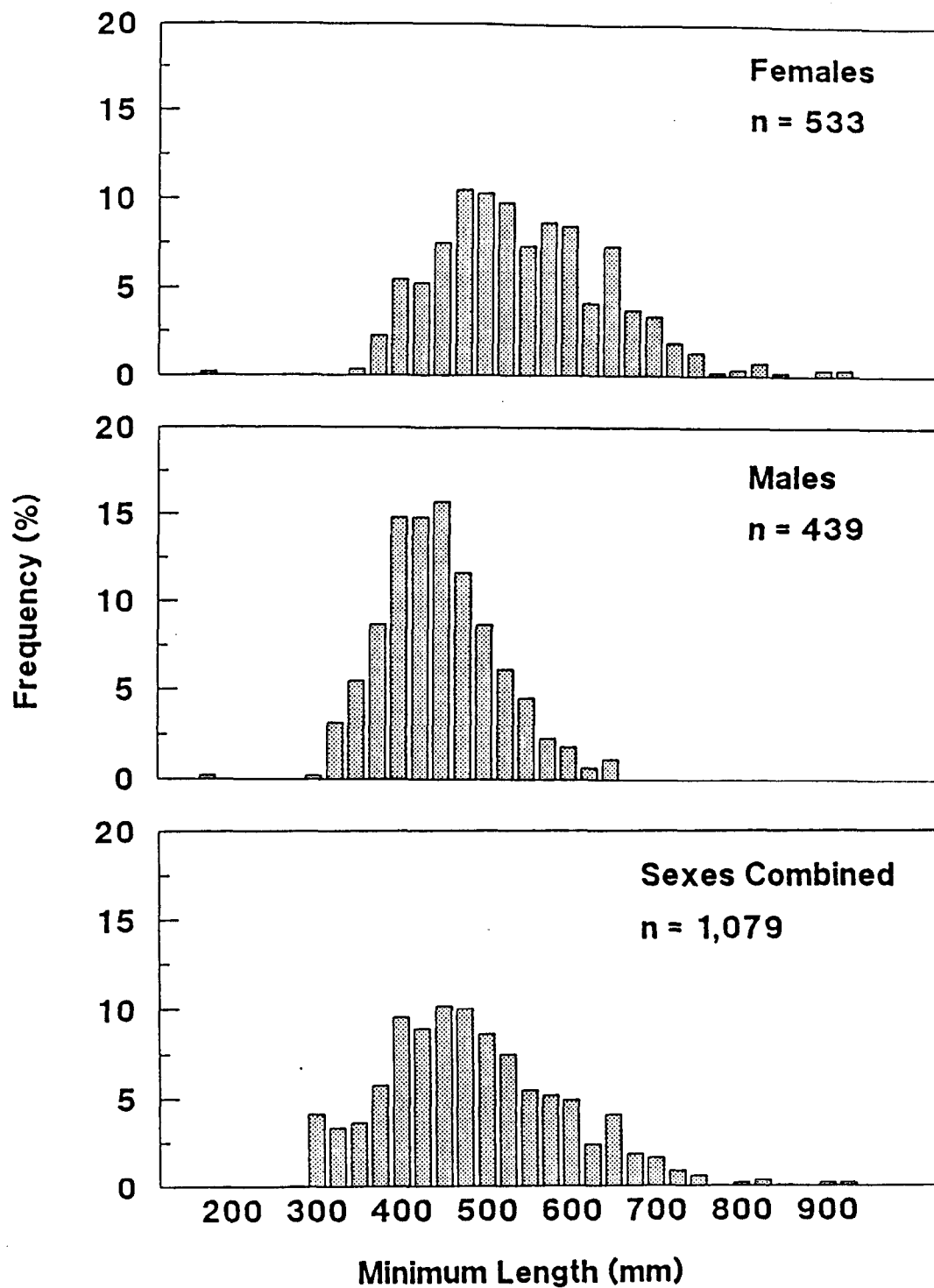


Figure 2. Length frequency distribution of northern pike in George Lake in 1988.

Table 4. Mean length (mm), by age and sex, of northern pike in George Lake in 1988.

Age	Females			Males			Sexes Combined		
	Mean	n	SE	Mean	n	SE	Mean	n	SE
2	357	1	0	347	3	12	327	56	3
3	427	41	5	412	107	3	408	174	3
4	482	106	4	451	135	3	462	251	3
5	536	89	5	494	48	8	520	139	5
6	572	95	8	524	31	8	564	126	5
7	636	50	6	563	23	10	613	73	7
8	652	22	9	623	4	25	648	26	9
9	722	11	10				715	12	12
10	705	11	16	651	1	0	700	12	15
11	750	5	24	670	1	0	737	6	23
12	822	3	35				822	3	35
13	818	2	13				818	2	13
14	945	1	0				945	1	0
Total		437			353			881	

Table 5. Age composition of northern pike (&gt; 299 mm) in George Lake in 1988.

Age	n	Percent	SE %	Abundance	SE Abundance
<u>Females</u>					
2	1	0.23	0.23	29	29
3	41	9.38	1.40	1,203	376
4	106	24.26	2.05	3,110	901
5	89	20.37	1.93	2,612	764
6	94	21.51	1.97	2,758	805
7	50	11.44	1.52	1,467	449
8	22	5.03	1.05	646	221
9	11	2.52	0.75	323	129
10	11	2.52	0.75	323	129
11	5	1.14	0.51	147	75
12	3	0.69	0.40	88	55
13	2	0.46	0.32	59	43
14	1	0.23	0.23	29	29
Total	437			12,823	3,567
<u>Males</u>					
2	19	5.15	1.15	544	191
3	107	29.00	2.37	3,061	887
4	135	36.59	2.51	3,863	1,107
5	48	13.01	1.75	1,373	422
6	31	8.40	1.45	887	288
7	23	6.23	1.26	658	224
8	4	1.08	0.54	114	63
9	0	0.00	0.00	0	0
10	1	0.27	0.27	29	29
11	1	0.27	0.27	29	29
12	0	0.00	0.00	0	0
13	0	0.00	0.00	0	0
14	0	0.00	0.00	0	0
Total	369			10,558	2,944
<u>Sexes Combined</u>					
2	56	6.34	0.82	1,483	450
3	174	19.71	1.34	4,607	1,310
4	251	28.43	1.52	6,646	1,871
5	139	15.74	1.23	3,681	1,055
6	128	14.50	1.19	3,389	975
7	73	8.27	0.93	1,933	574
8	26	2.94	0.57	688	229
9	12	1.36	0.39	318	124
10	12	1.36	0.39	318	124
11	6	0.68	0.28	159	76
12	3	0.34	0.20	79	49
13	2	0.23	0.16	53	39
14	1	0.11	0.11	26	26
Total	883			23,381	6,471

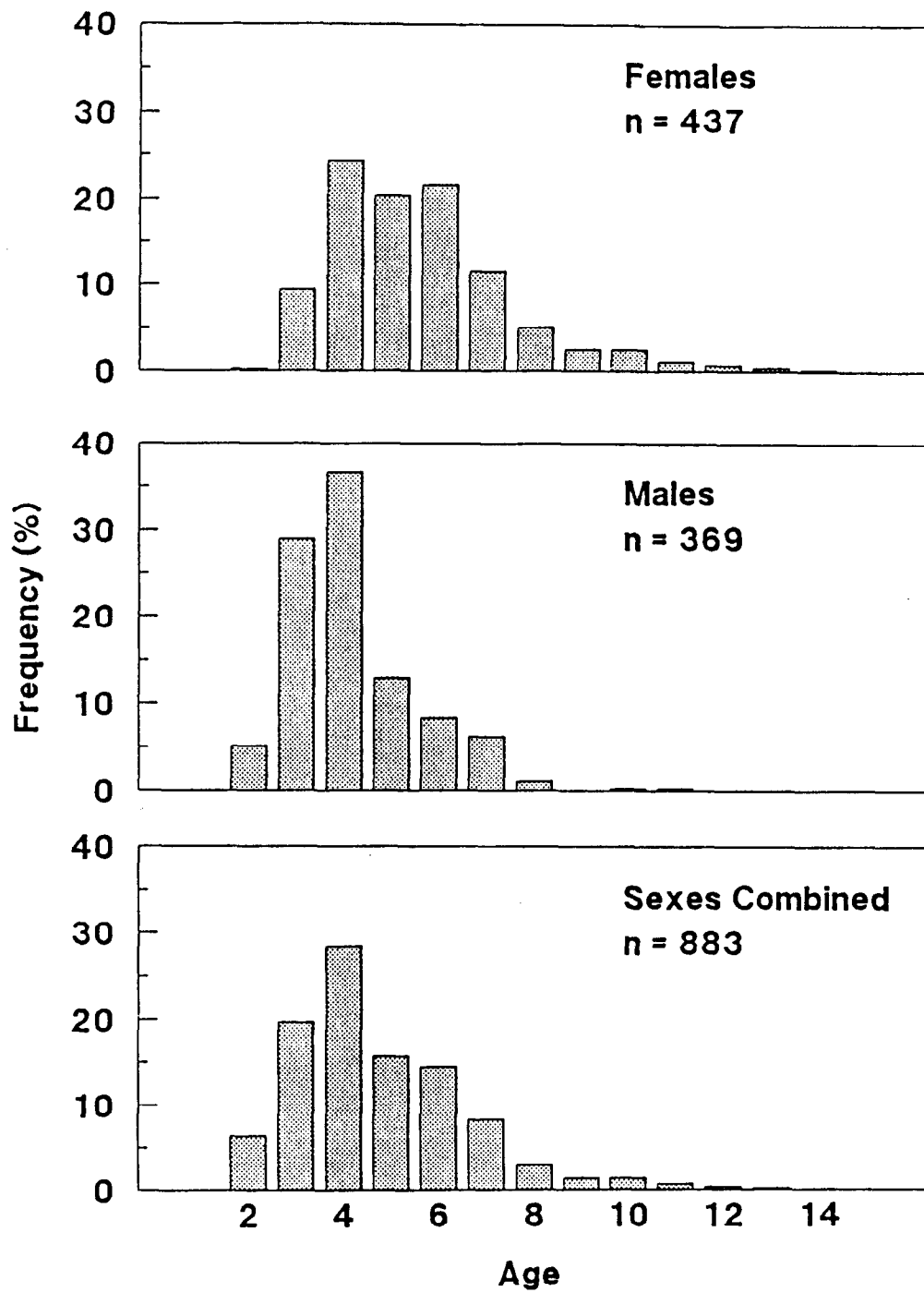


Figure 3. Age distribution of northern pike in George Lake in 1988.



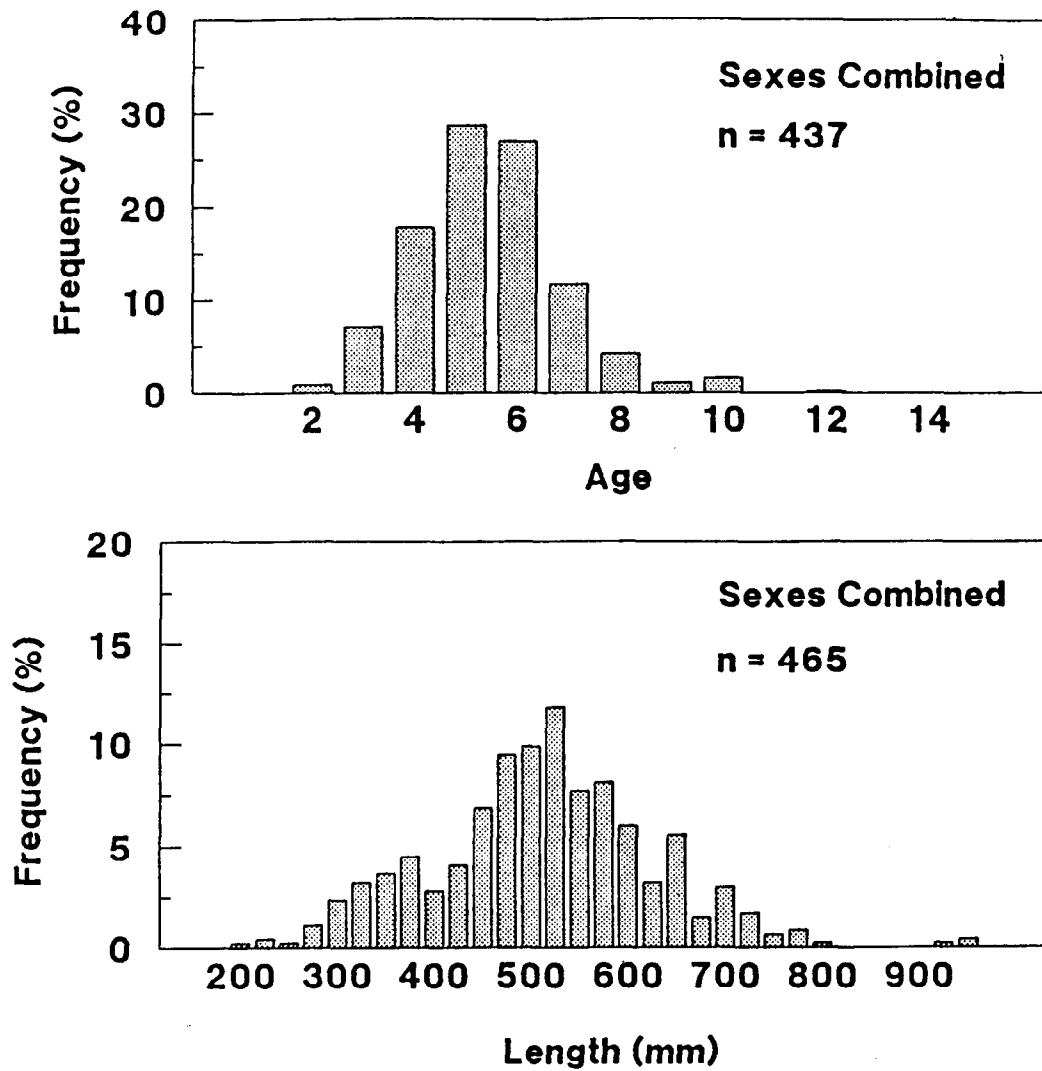


Figure 4. Length and age distributions of northern pike in Volkmar Lake in 1988.

Table 6. Mean length (mm) by age (sexes combined) of northern pike sampled from Volkmar Lake in 1988.

Age	Mean Length	n	SE
2	292	4	18
3	352	31	11
4	441	77	8
5	515	124	7
6	570	117	7
7	622	51	13
8	642	18	22
9	627	5	22
10	737	7	35
12	972	1	0
Total		435	

Table 7. Parameter estimates of the von Bertalanffy growth equation for Volkmar, George<sup>1</sup>, and T<sup>2</sup> Lakes.

Sex	$L_{\infty}$	SE $L_{\infty}$	K	SE K	$t_0$	SE $t_0$	Correlation Coefficients			n
							$L_{\infty}/K$	$L_{\infty}/t_0$	$K/t_0$	
<u>Volkmar Lake</u>										
Females	1,079	52	0.12	0.01	-0.56	0.25	-0.98	-0.86	0.94	1,022
Males	741	19	0.25	0.02	0.48	0.15	-0.95	-0.76	0.92	825
<u>George Lake</u>										
Females	1,030	97	0.13	0.03	-1.00	0.52	-0.99	-0.91	0.96	400
Males	971	242	0.09	0.05	-2.94	1.16	-0.99	-0.94	0.97	347
<u>T Lake</u>										
Females	965	94	0.15	0.04	0.11	0.84	-0.98	-0.85	0.94	164
Males	887	170	0.14	0.06	-0.20	0.80	-0.99	-0.88	0.94	108

<sup>1</sup> Clark et al. 1988.

<sup>2</sup> Clark 1988.

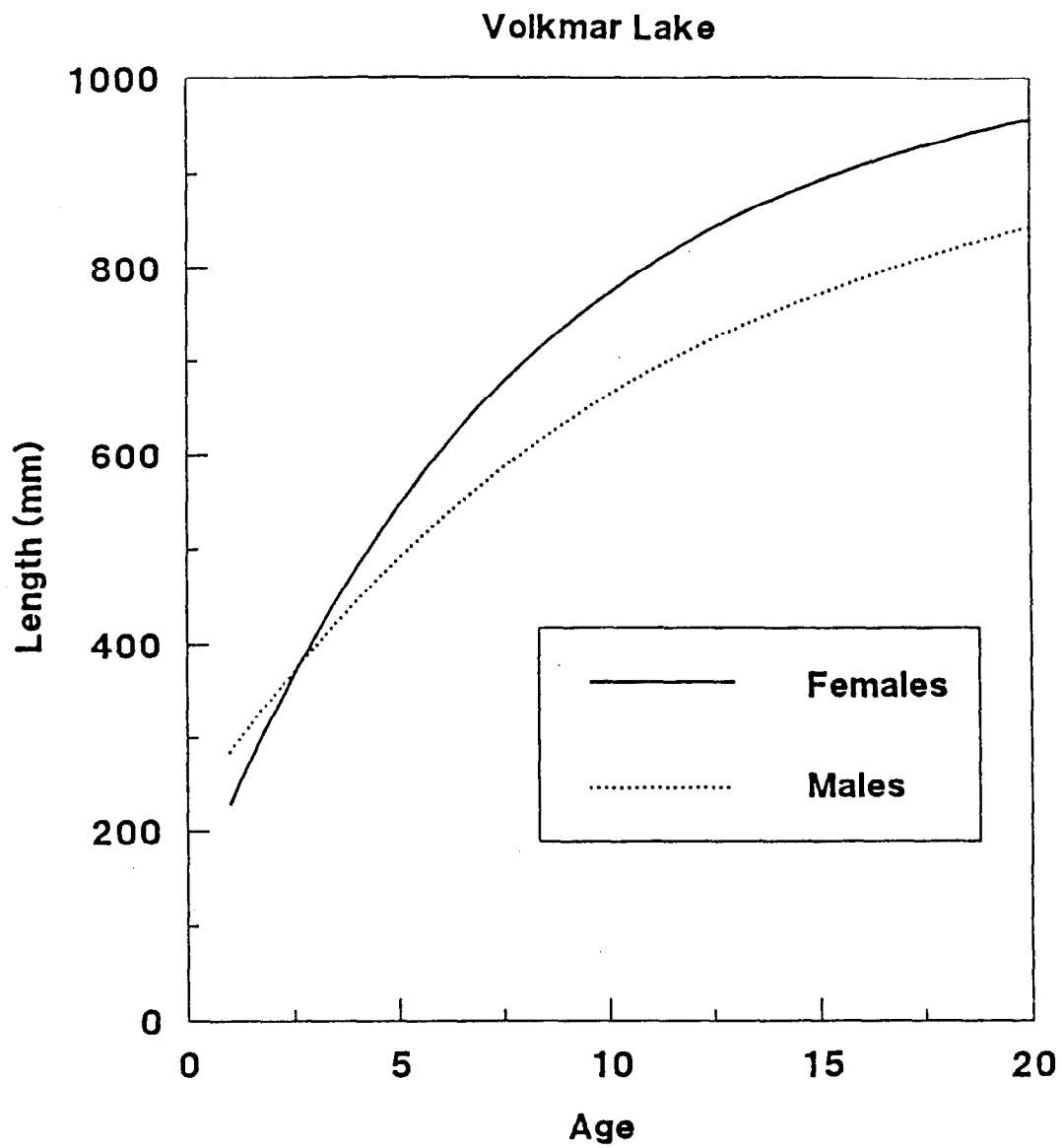


Figure 5. Von Bertalanffy growth curves of male and female northern pike in Volkmar Lake.

## T Lake

A total of 325 northern pike was sampled in T Lake in 1988, including recaptured fish. During the first sampling event, 164 fish were released with tags. During the second event, 143 fish were examined for tags, of which 50 were tagged recaptures from the first event. Estimated abundance of northern pike larger than 299 mm in T Lake in late May of 1988 was 465 fish (SE = 43). Most northern pike in T Lake were in the stock (37%), quality (35%), or preferred (25%) categories (Table 2); few fish were larger than 859 mm. The density of northern pike 300 mm and longer was estimated to be 2.9 fish/ha.

The T Lake population of northern pike was made up of an estimated 223 (48%) females and 242 (52%) males (Table 3). Males dominated the small length categories, while females dominated the large categories (Figure 6). Females were generally larger than males for a given age (Table 8). Female northern pike were most abundant in the 6, 7, and 8 age classes, while males were most abundant in the 5, 6, and 7 age classes (Table 9). The oldest northern pike captured in T Lake in 1988 was age 14. Females appeared to be completely recruited to the sampling gear by age 8 and 675 mm, while males were completely recruited by age 6 and 500 mm (Figures 6 and 7). Numbers of fish falling within the small, medium, and large categories are given in Appendix Table 2.

## DISCUSSION

George Lake had the largest population of northern pike (> 299 mm) of the three lakes studied, assuming that the Volkmar population was approximately the same size in 1988 as it was in 1987 (6,998, SE = 1,278). Significant differences in abundance of northern pike in George and T Lakes between 1987 and 1988 were undetectable, due at least in part to relatively large sampling errors in both years.

Large sampling errors constrain comparisons of cohort strength across years. Estimates of abundance based on age, including age-length correlations, are also biased by inaccurate age determination. Although scales provide relatively precise ages for Alaskan northern pike (Timmons & Bernard 1989)<sup>1</sup>, accuracy of ages obtained from scales has been shown to be limited (Williams 1955, Casselman 1967). In this study, many errors in age determination were revealed when ages from tagged fish, which were recaptured and aged across more than one year, were compared. Due to such obvious problems in the accuracy of ages determined from scales, a study of age validation (accuracy) for stocks of northern pike in interior Alaska is planned for 1989.

Relative stock densities of northern pike in George Lake remained relatively constant between 1987 and 1988, although the RSD of preferred fish increased from 4.7 to 8.9 and the RSD of memorable fish increased from 0.0 to 0.4. From 1987 to 1988, Volkmar Lake saw a decrease in the RSD of stock northern pike, with a corresponding increase in quality and preferred fish. In T Lake, the

<sup>1</sup> Timmons, L. and D. Bernard. 1989. Personal Communication. ADFG, 1300 College Rd., Fairbanks, AK 99701.

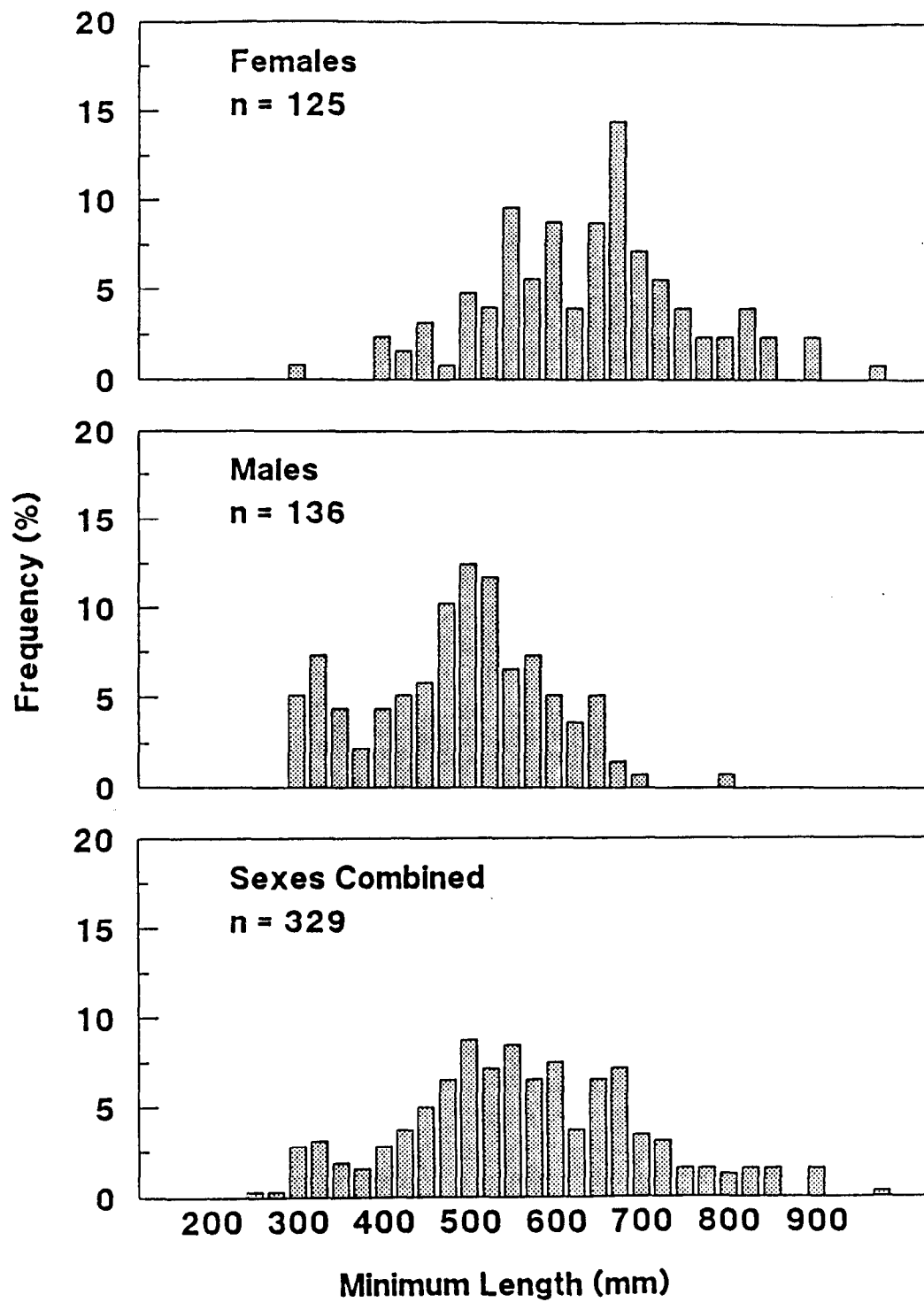


Figure 6. Length frequency distribution of northern pike in T Lake.

Table 8. Mean length (mm), by age and sex, of northern pike from T Lake in 1988.

Age	Females			Males			Sexes Combined		
	Mean	n	SE	Mean	n	SE	Mean	n	SE
2		0			0		252	1	
3		0		336	6	8	327	7	11
4	304	1		361	12	17	365	15	16
5	529	5	44	445	23	19	455	29	18
6	565	21	15	513	32	10	532	57	9
7	620	24	15	528	27	12	573	54	11
8	658	26	14	579	12	13	632	40	26
9	734	9	37	643	6	24	698	15	49
10	688	14	60	589	3	41	672	17	30
11	777	4	35	667	3	4	730	7	35
12	798	7	40	820	1		800	8	35
13	821	1					821	1	
14	989	1					989	1	
Total		113			125			252	

Table 9. Age composition of northern pike in T Lake in 1988.

Age	n	Percent	SE %	Abundance	SE Abundance
<u>Females</u>					
2	0	0.00		0	
3	0	0.00		0	
4	1	0.88	1.00	2	2
5	5	4.42	2.00	10	5
6	21	18.58	4.00	41	9
7	24	21.24	4.00	47	10
8	26	23.01	4.00	51	11
9	9	7.96	3.00	18	6
10	14	12.39	3.00	28	8
11	4	3.54	2.00	8	4
12	7	6.19	2.00	14	5
13	1	0.88	1.00	2	2
14	1	0.88	1.00	2	2
Total	113			223	25
<u>Males</u>					
2	0	0.00		0	
3	6	4.80	2.00	12	5
4	12	9.60	3.00	23	7
5	23	18.40	3.00	45	10
6	32	25.60	4.00	62	12
7	27	21.60	4.00	52	11
8	12	9.60	3.00	23	7
9	6	4.80	2.00	12	5
10	3	2.40	1.00	6	3
11	3	2.40	1.00	6	3
12	1	0.80	1.00	2	2
13	0	0.00	0.00	0	0
14	0	0.00	0.00	0	0
Total	125			242	27
<u>Sexes Combined</u>					
2	1	0.40	0.00	2	2
3	7	2.78	1.00	13	5
4	15	5.95	1.00	28	7
5	29	11.51	2.00	54	11
6	57	22.62	3.00	105	16
7	54	21.43	3.00	100	15
8	40	15.87	2.00	74	13
9	15	5.95	1.00	28	7
10	17	6.75	2.00	31	8
11	7	2.78	1.00	13	5
12	8	3.17	1.00	15	2
13	1	0.40	0.00	2	2
14	1	0.40	0.00	2	0
Total	252			465	43



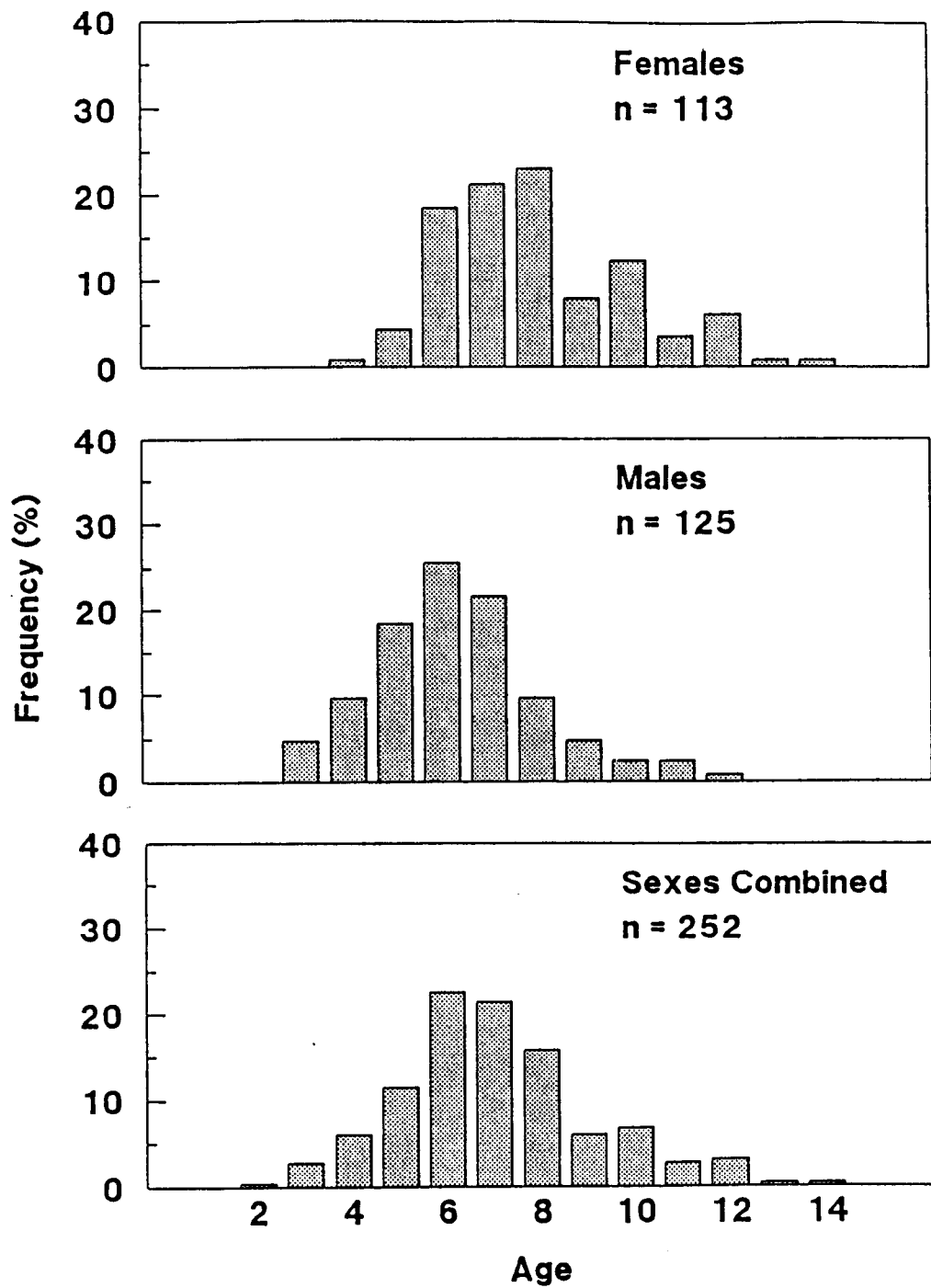


Figure 7. Age distribution of northern pike in T Lake in 1988.

RSDs remained relatively constant between 1987 and 1988, but declined in the quality and preferred categories compared with 1986 composition estimates. T Lake had a greater relative stock density of larger ( $> 655$  mm) fish than did George or Volkmar Lakes, but showed a lower abundance of fish in the stock (300-524 mm) category, possibly due to a lower level of recruitment. No attempt was made to determine if these changes were statistically significant.

In both George and T Lakes, males dominated the younger, smaller size groups of the populations in 1988, while females dominated the older, larger size groups. The estimated sex composition of northern pike ( $> 299$  mm) in George Lake was 55% females and 45% males in 1988, compared to 64% and 36% in 1986, and 53% and 47% in 1987, respectively (Clark et al. 1988). In the T Lake population ( $> 449$  mm), males (52%) outnumbered females (48%) in 1988, whereas females outnumbered males in 1986 (56% vs. 44%) and in 1987 (72% vs. 28%) (Clark 1988). Caution should be exercised when comparing sex-dependent databases both within and between waterbodies over time. Although we closely followed the guidelines of Casselman (1974) for external sex determination, unless sex products are readily expressed upon examination, assignment errors can occur, particularly with smaller fish. Faulty sex determination is occasionally detected in our multi-year database, when recaptured northern pike are assigned different sexes in different years. This is, no doubt, a function of observer error in identifying the sex of live northern pike in the field.

Growth of female northern pike in George, Volkmar, and T Lakes was very similar, but males grew differently, particularly in Volkmar Lake, for which males had a much lower  $L_{\infty}$  (Figure 8). No attempt was made to relate the parameters of the model to the mechanisms underlying the growth process, but further studies may provide this information.

Among the lakes studied, current data on sport fishing harvest is only available for George Lake. Clark et al. (1988) discussed known exploitation in 1986 for T Lake pike over 449 mm (10%), and Volkmar Lake (from 8%,  $> 299$  mm to 16%,  $> 449$  mm F1). In George Lake, estimated yearly angler harvest in 1987 (Mills 1988) was 2,229, which amounted to approximately 13% of the estimated population in May, 1987 (17,662) greater than 299 mm or 26% of the population over 449 mm (8,495). Harvest data for 1988 is, as of yet, unavailable. However, assuming a similar harvest level in 1988 (2,229), exploitation would be about 9.5% of the estimated population in May, 1988 (23,381) greater than 299 mm or 13% of the estimated population (16,680) over 449 mm. These levels applied to the point estimates are probably sustainable. The current sport-caught daily bag and possession limit for the studied waters is five northern pike per day, of which only one may be over 762 mm (30 inches) total length, or approximately 682 mm (27 inches) fork length. The effects of this limit, which was established in early 1987, need to be documented in case implementation of additional conservation measures becomes necessary. Continued assessment of levels of northern pike populations, mortality rates and recruitment levels is recommended to establish models of potential yield for the species in Alaska. In addition, to complement our investigations of northern pike and to improve existing harvest studies, we recommend establishing an expanded creel census program and additional angler surveys to

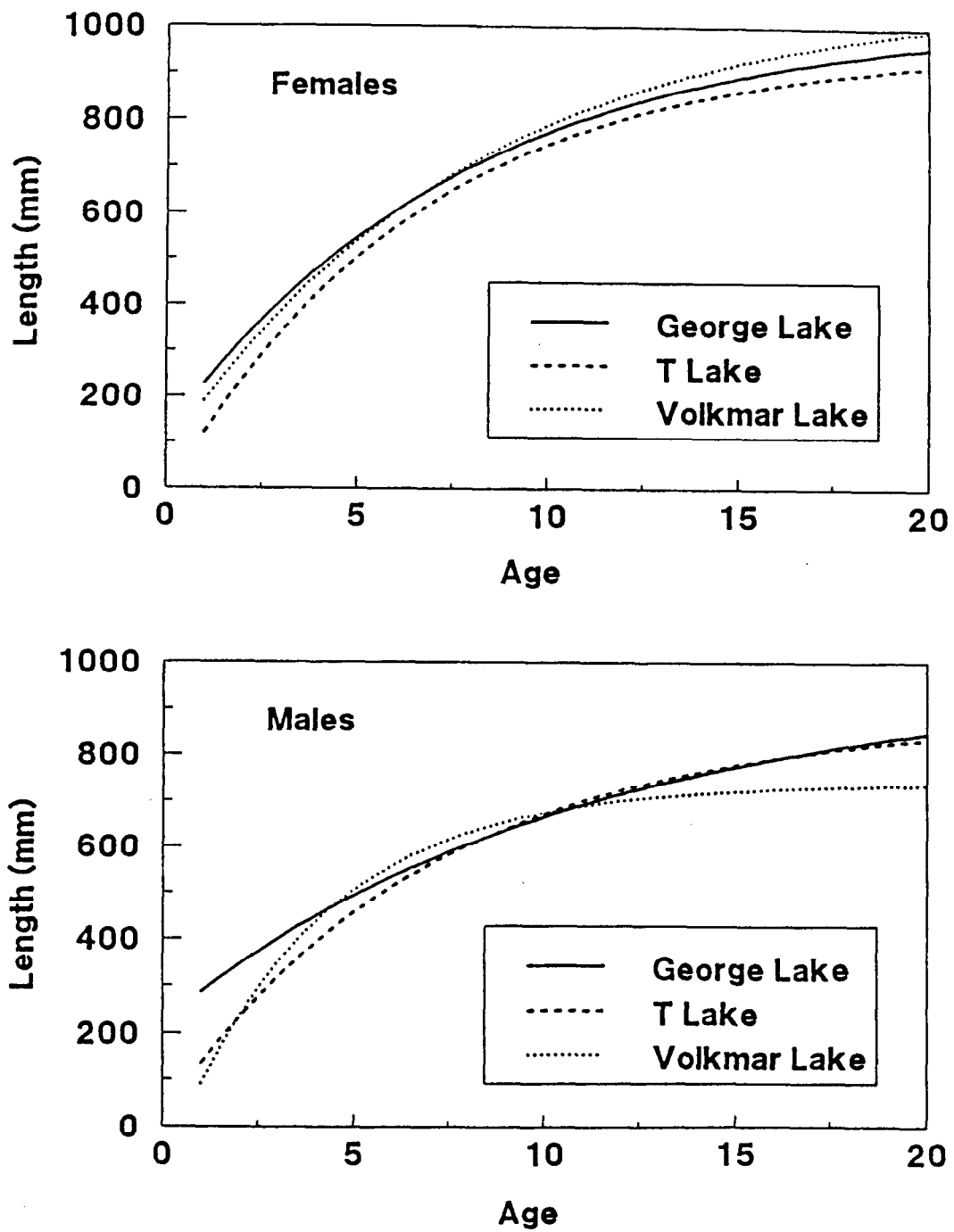


Figure 8. Von Bertalanffy growth curves of female and male northern pike in George, Volkmar, and T Lakes.

determine seasonal fishing trends, catch composition, fishery exploitation and angler preferences for these northern pike fisheries.

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## APPENDIX

Appendix Table 1. Fin clips and tags assigned to northern pike in George, Volkmar, and T Lakes.

Year	Tag Series	Color	Fin Clips <sup>1</sup>	Comments
<u>George Lake</u>				
<1983	Jaw Tags		None	
1983	16197 - 16206	Red	None	
1984	16221 - 16305	Red	None	
1985	No Sampling			
1986	3000, 4000, 17000	Yellow Red	004	Coded LV in original data.
1987	20000, 30000 17715 17836 - 17999	White  Red	 008 002	 Most tagged fish given 008; when ran out of tags, gave 002; a few tagged fish given 002.
1988	62000 - 62356 96000 - 97999	White Green	064	
<u>Volkmar Lake</u>				
1983	16189 - 16196 174 - 214	Red Blue	None	
1984	16207 - 16347	Red	None	
1985	16431 - 17568	Red	None	
1986	3000, 4000 16000, 17000 20400 - 20454	Yellow Red White	016, 032 Many odd combos	032 = fish >499 mm; mostly untagged fish during marking run; mostly tagged fish during recap run. 016 = fish <500 mm; most tagged. Odd 16000, 17000 series tags from previous years.
1987	25000 - 26037	White	008 Many odd combos	
1988	98000 - 98355	Green	064 Many odd combos	
<u>T Lake</u>				
1986	3247 - 3618	Yellow	002 004 032	002 = accidental wrong clip; 004 = Mark Run; 032 = Recap Run.
1987	17569 - 17834	Red	008	
1988	99000 - 99139	Green	064	

<sup>1</sup> Fin Clip Codes: 001 = Adipose, 002 = R. Pelvic (Ventral), 004 = L. Pelvic (Ventral), 008 = R. Pectoral, 016 = L. Pectoral, 032 = U. Caudal, 064 = L. Caudal.

Appendix Table 2. Abundance of small (300-449 mm), medium (450-749 mm), and large (> 749 mm) northern pike in George, Volkmar, and T Lakes in 1986, 1987, and 1988. <sup>1</sup>

Length Class (mm)	1986		1987		1988	
	<sup>^</sup> N	<sup>^</sup> SE N	<sup>^</sup> N	<sup>^</sup> SE N	<sup>^</sup> N	<sup>^</sup> SE N
<u>George Lake</u> <sup>2</sup>						
Small	—	—	9,167	978	8,264	2,310
Medium	—	—	8,195	1,031	14,705	4,083
Large	—	—	300	342	412	145
Total						
>299 mm	—	—	17,662	2,105	23,381	6,471
>449 mm	—	—	8,495	1,086	16,680	4,628
<u>Volkmar Lake</u> <sup>2</sup>						
Small	4,027	2,266	5,130	1,242	—	—
Medium	3,890	584	1,386	294	—	—
Large	136	65	482	76	—	—
Total						
>299 mm	8,053	2,341	6,998	1,278	—	—
>449 mm	4,026	587	—	—	—	—
<u>T Lake</u> <sup>2</sup>						
Small	—	—	107	18	73	12
Medium	412	37	452	53	350	34
Large	42	5	64	13	42	9
Total						
>299 mm	—	—	623	70	465	43
>449 mm	454	37	516	54	392	35

<sup>1</sup> Estimates for 1986 and 1987 are taken from Clark et al. (1988), Clark (1988), and Clark and Gregory (1988).

<sup>2</sup> Estimates of abundance were not available for George Lake in 1986, fish < 450 mm in T Lake for 1986, and for Volkmar Lake in 1988.

